THE IMPACT OF EDP ON

MANAGEMENT ORGANIZATION AND MANAGERIAL WORK

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Most technological changes introduced by management to improve efficiency and to push the enterprise in new directions have had a greater impact on other groups in the organization - on production workers or white collar employees - than on management personnel directly. But the computer age is changing this. Electronic data processing, which in many ways is still in its infancy, has already had a substantial impact on the organization of management and on the nature of managerial work. And it is probable that the major impacts lie ahead, as computer technology (both "hardware" and "software") advances still further. The computer expands human brainpower in management, but also replaces some in managerial work.

Electronic data processing associated with the computer revolution is scarcely 15 years old, although the first electronic computer was built in the 1940's. Much has already been written and some research has been done on the implications of EDP for management. It will be the purpose of this paper to review briefly the significant findings under several headings, and to indicate what the M.I.T. group has already learned in its initial research on the same topics. We shall first consider the distinctions between past, present, and future possibilities in EDP, then the total system concept, the consequences of this for management organization, the impacts on management activities, the problem of introducing change, and the consequences for subordinate levels of management in relation to managerial motivation. In all of this, the emphasis will be on what might be as well as on what has been or is true of the impact of EDP. References to the literature will largely be to the selected bibliography at the end of this paper.

Past, Present and Future: A Brief Review

Some idea of the rapid spread of computers in industry can be gathered from the first McGraw-Hill "Survey of Computers and Computer Usage," released April 9, 1965. "There are nearly 5,000 electronic computers in operation in about 650 of the largest U.S. corporations representing every major industry. Only 20 per cent of the 800 companies reporting indicated that they currently do not have any computer installations of their own." About 70 per cent of the computer-using companies reported that their computers were less than three years old. The highest numbers of computers were in industries like insurance, banking, communications, aerospace, chemicals, petroleum, automobiles, and machinery and electrical machinery manufacturing.

The time sequence of EDP applications is illustrated by the percentage of companies indicating each of the following applications:

Accounting	99
Inventory control	74
Production planning & control	58
Scientific & Eng. applications	47
Business Forecasting	33
PERT	25

For manufacturing alone, the percentages would all be higher, but the rank order is the same. Other uses with less than 25 per cent of the companies indicating them, were transportation, process control, data acquisition, and location selection. Personnel records and other analyses of personnel work were not listed, but these applications are spreading. (Austin, Bueschel) Marketing applications of EDP are also growing (Business Week, April 17, 1965). (In a report for OMAT in 1964, the Diebold Associates estimated that there were fewer than 400 general purpose digital computers in operation in 1955, and over 11,000 by 1962; the latest estimate for 1964 is about 13,000. The McGraw-Hill Survey is a sample only.)

This is essentially a picture of developments from the past and the recent present. As Burck has put it, "Most of the profitable operations are still confined to such routine jobs as fulfilling payrolls, making out accounts payable and receivable, and processing insurance data, but even these applications are growing vastly more refined." (p. 12) Inventory control is more recent and spreading; as is production and manpower scheduling and control, particularly via PERT. Some of these applications are aided by the simulation of alternatives through mathematical models, but simulation of entire business operations is also a recent development (Forrester).

With advanced computers, "real time" as opposed to delayed time applications are spreading. Real time systems provide management with data as rapidly as needed, in a few minutes in some cases and longer periods in others, to control events or circumstances while they are still happening. (Lombardi) The data supplied are "on line" (i.e., supplied to the user as soon as they are recorded) and the possibility of man-computer interaction is greatly increased in a feedback or servomechanism sense. Apparently there are only a few broadly integrated "on line and in real time" systems now in operation, including American Airline's SABRE, Westinghouse, Lockheed, and Louisville & Nashville Railroad. But by 1970, it is predicted, "nearly all new electronic data-processing systems will be on line in real time." (Burck, p. 28)

Time-Sharing systems, based on computers with very large memory banks, provide almost instantaneous access to the computer by a number of different people at remote locations. M.I.T.'s "Project MAC" (Multiple Access Computer or Machine-Aided Cognition) is a prototype of this development, but the major industrial applications are still ahead, as we shall note later. One of these is the computer utility. So is direct voice communication, and "natural" languages of which COBOL and others are advance samples. Computer-aided design, in which M.I.T.'s "Sketchpad" is the first application, is another development which will spread.

The increasing possibility that managers can interact directly with computers is of great significance, as the experience with Project MAC and with such industrial applications as the Westinghouse Telecommunications Center, already indicate. As Jacob Ever of IBM has observed:

> "In a few years there will be a great upsurge in central corporate systems just as today we witness an exploding use of time-sharing in the scientific community.....The advent of the 'third generation' of computers with extensive random access files, multiprogramming and communication facilities (at sharply reduced costs) will greatly advance the economic and technical feasibility of central corporate systems..."
> Industrial Management Review, Spring 1965, p. 78.

EDP and the Concept of the Organization as a Total System

One central conclusion emerges from the onrush of computer technology and the thinking of those who have concerned themselves with improving the efficiency of management controls in achieving organizational objectives: EDP makes operational the concept of an organization as a total system. In Beckett's phrase, a total system is "an all-embracing formalized system for the operating aspects of business as a whole... Probably no American business has reached this formalized 'total system' yet, though many are working on it." (pp. 14-15) Bekcett has coined the word, "systemation" - "the wedding of man and machines in a fully planned program for operations." (p. 17) As Orden has explained:

> "...without the computer the entity as a whole could not be sufficiently regularized to form a 'system'. The computer may contribute to systematization in a variety of ways--as a high-speed information processor and transmitter, as a reducer of the 'human factor' content of the situation, or as a control component for parts of the system. The significant thing is that, over and above such factors, the use of the computer makes it possible to view an entire complex business situation as a system." (Shultz and Whisler, p. 74)

However, Burck has noted that, "Perhaps the nearest thing to a total system is SAGE; but business is much more complex than cold war, and it will be a long while before the business equivalent of SAGE is working." (p. 16)

Nevertheless, those interested in management controls through advanced management information systems are working toward the total system objective. The contention is that "the organization structure of the firm and the control system must impose relative limitations (ranges) on the freedom of the individual." (Zannetos, The Accounting Review, October 1964, p. 866). The new and forthcoming information technology, through advanced computers, gives the proponents of total management control systems the means by which these systems can be effectively implemented. Yet these systems will require substantial changes from the past systems, as John Diebold has pointed out in a provocative article:

> "The new information systems will not be merely more mechanized versions of today's 'computer applications,' which are themselves simply perpetuations on tape of yesterday's punched-card runs. The on-line multi-processing system, linking many remote sites together through a digital communications net, is a total departure from today's computerized tab rooms." (ADP--The Still Sleeping Giant, p. 64)

The "total systems" approach has its critics, however. John Dearden of the Harvard Business School asserts that it "implies a central control of the systems effort" and "is leading us in the wrong direction." (Harvard Business Review, March-April 1965, p. 66). In an earlier article, he asserted that "operational control systems" (such as production scheduling) were adaptable to computerization, but management control systems based on budgetary controls will not be greatly improved by this kind of automation. The problem lies in faulty methods of collecting data, not in processing them." (pp. 132-134) His is a minority voice, though an arresting one, against the "total system" tide.

Consequences for Management Organization

Even if EDP is not yet part of a total system concept, it has already had significant effects on the structure of management organization. To the extent that a management control sytem of some sort is facilitated by the computer, there is more "management by rule or procedure," and less room for managerial discretion at the lower levels. The computerized system imposes a consistent discipline on those affected by it. They must comply with the requirements of the inputs to the system and be guided by its outputs. Since decisions about the design of a system of managerial controls are made at higher levels in management, the clear implication is that both in its design and its implementation, the computerized system results in a more centralized organization structure.

When this result is combined with the further point that EDP makes possible centralization of many functions which were performed regionally before, the centralization tendency is even clearer. For example, among other consequences of the Telecomputer Center at Westinghouse are the following:

> "The stock control function, formerly performed in the field, is now performed centrally. The regional order service manager has disappeared and a central order service function has been strengthened. The regional accounting organization has been completely eliminated in the last three years, with the invoicing function performed centrally and the accounts payable function split between headquarters accounting and the field sales offices on a dollar value basis. The shift from regional to central accounting and order service has occurred as a result of changing management philosophy. This change in philosophy has gone hand in hand with the economies afforded by centralized computerization of the order entry system." (Strauss, Industrial Management Review, Spring 1965, p. 68)

A recent study of "The Impact of Numerically Controlled Equipment on Factory Organization" reached a similar conclusion:

> "Under Numeric Control, new decision-making groups are introduced, such as parts programming and often data processing. In addition, the route and rate of decisions are usually modified to centralize many decisions at one time and in one place...Frequently, decision making moves from the shop floor to the office...Essentially, units become more interdependent and have fewer areas of freedom." (Williams and Williams, pp. 26, 28)

The claim that computerization will result in more centralized management is not a new one. Leavitt and Whisler pointed to it in their 1958 Harvard Business Review article. So did Shultz and Whisler in their summary chapter on papers and discussion at the McKinsey Seminar in 1959 (p. 30). More recently, Whisler has summarized his later studies pointing to the same tendency. One involved production planning in manufacturing, and the other is an effort to measure the degree of centralization by an "index of inequality in compensation" as well as by scaling members' perception of control or authority relationships in groups. (Whisler, IILS paper and paper in Cooper, Leavitt and Shelly.)

Another attempt to determine the degree of centralization involves a more precise definition of the terms "centralization" and "decentralization," which are relative--not absolute--terms. Conceptually,

> "a unit is decentralized absolutely, always of course within the overall objectives of the firm, if and only if its index of substantive...objectives is qualitatively identical to those of its parent..... Nothing can be said, however, about the degree of centralization or decentralization at any level unless an analysis is made of the relationship between overall objectives and subunit objectives." (Zannetos, Management Science, ms. 11)

This proposition, which may be difficult to test empirically, does suggest analytically the possibility of effective decentralization with EDP, as Zannetos suggests. We shall return to this important possibility in a later section. It is not yet proven that the centralization which apparently results under EDP is more efficient in every case. And the consequences for the development of more capable management personnel in operating as well as planning functions have hardly been explored.

Case Study: Computerized Inventory Control Leads to More Centralization

One of the Masters' theses (by a Sloan Fellow) under the M.I.T. research program examined the impact of a computer system for inventory control on the home office and 25 depots of a parts service division of a large consumer durable goods manufacturing company (Chabot, June 1965). Interviews and internally-supplied data were the basis for the major conclusions that there was more centralization of control in the divisional (home) office as a result

of computerization which started in 1960. "There were organizational moves toward centralization, apart from the computer system," the study found, "but it is clear that the information system with the computer has facilitated this process greatly."

The major advantage of the new system, in the opinion of the divisional general manager, was "discipline."

> "Several characteristics were implied in this one heading--the demand for correct and prompt handling of detail at the worker and foreman level; the demand on supervisors and managers for a clear understanding of the physical system and the information system; and the realistic appraisal of performance resulting from the information system that is available to the central office as well as the depot management." (p. 50)

As a consequence of more centralization in the divisional office, 25 supervisory positions were eliminated in the depots and three new ones added at the divisional home office. Taking into account the impact of both the inventory system and a more recent accounting centralization, the total supervisory and non-supervisory field personnel were reduced by 460 and home office personnel increased by 210 (p. 36). Among the affected supervisors, some were promoted or transferred to the home office (with moving allowances), some were demoted, and some were retired or quit. Most of the latter three outcomes applied to supervisors who could not adjust to the new centralized system and its requirement at the depot level.

The computerization process by which this centralization occurred may be summarized briefly. Each day the field depots air-ship activity cards that contain the data on vendor shipments received, orders shipped to dealers, lines not filled and placed on back order, error corrects, etc. Altogether, about 80,000 cards are sent to the central office daily for inventory purposes. The significant thing for centralization is that none of the depot personnel, including the manager, knows the significance of the daily shipment of information until five work days later at the earliest, while the home office division manager knows this earlier. Formerly, stock record clerks were responsible for the daily posting of receipts and shipments, so that the depot manager could be informed immediately (and could tell a dealer) about the inventory status of a part.

About 13,000 parts are ordered from vendors and allocated to the depots by the computer program. (Over 12,000 faster selling parts are not part of the computer program and are still purchased by merchandisers of the

Supply Department.) The system requires great accuracy by depot personnel, because misreading a part number, misplacing parts, etc., will result in computer reporting of "lost parts" if a "properly trained and motivated" supervisor has not earlier put through a correction (Chabot, examples, pp. 18-19, 25). "An error of miscounting inventory by 18,000 units was cited as an example of the need for education at the worker level. Two workers were making an inventory count; one reported to the other 'two thousand one units' (2001), the second worker recorded 20001." (p. 27) However, the centralized system exposes errors, forcing the depot managers to take action to correct them. "The home office is aware of the error five days after the event; one to three days later the depot is informed of its error by the home office. The depot manager starts an investigation." (p. 44) These are examples of the "discipline" which the home office division manager cited as a great advantage of the central computerized inventory control system.

Offsetting the loss of independence by depot managers and supervisors, however, was the advantage to them of knowing that their performance is being reported objectively:

> "Prior to the system introduction, the depot performance reports were under the control of the depot managers and were subjected to significant distortion not only by him, but by the supervisors reporting to him as well. From the point of view of the 'old' manager, he knew his performance, or thought he did, but wondered if the other managers reporting much better results were not distorting their reports much more than he. He did not have very much certainty about his real performance relative to the others. The computer system has largely eliminated this problem, and the manager has a much greater degree of security in the knowledge of his performance and of the supervisors working for him. The computer system reports can be distorted but the risks are considerable and the reports become less useful." (p. 47)..."It can be safely concluded that after the transition period, the ability of the computer system to report reality, to 'tell the truth,' about responsibility, was appreciated as an asset." (p. 52) "...Performance measurement of the depots improved tremendously with the advent of the computer system...Although viewed as a source of pressure by the depot personnel, especially the budget performance measurement, they are also recognized as a value within the depots in seeking out their own problems and corrections." (p. 53)

Finally, from the standpoint of the home office, the new system provided not only better discipline and better performance evaluation of the depots, but also better data for new kinds of analyses of questions which earlier would have taken a long time and would have cost far more to answer. Special studies can now be made, and "policy decisions based on fact rather than hunch." (p. 42)

Some Conflicting Conclusions on Centralization: Another Study

While the study summarized above supports the conclusion that an EDP system results in a more centralized organization structure, another Masters' thesis (by a Sloan Fellow) reached somewhat different conclusions, at least as applied to decision making. (Langstaff, June 1965) Interviews with officials of eight major companies which had installed EDP systems of various types, and more detailed case studies of two divisions in one company, led to the following conclusion:

> "No clear trend toward greater centralization in decision making was found in this study. Increased centralization of production planning with the help of the computer was encountered, but decentralization in decision making to lower levels of management was also found in the banking industry and in some manufacturing operation. In many areas of management, the increasing complexity of decisions favors a trend toward decision making at lower levels where a more detailed knowledge of the problem exists." (p. 95)

In the banking example (which is hardly a case of an integrated EDP system), investment decisions no longer had to be reviewed by a senior bank official because investment analyses could rely on the computer to supply data for decision making. On the other hand, a systems man in a company in a different industry cited the example of "the president calling the foreman directly to ask about some variation in performance based on a daily computer-generated report which he had requested" as a case of "over control from the top." Managers in another company saw a trend toward decision making at lower levels in the organization "if top management will show restraint" and let lower levels of management make these decisions with data supplied through the EDP system. (p.80) These comments are also relevant to the discussion in a later section of this paper.

Research on Changes in Organizational Structures of Life Insurance Companies

Some preliminary findings from a continuing study (by the M. I. T. group) of the impact of EDP in life insurance companies are relevant to the discussion of the organizational consequences of EDP generally. To the extent that a life insurance company in our sample (about 10 companies) has moved toward an integrated EDP system, with a central center getting inputs of data from a number of different traditional functions and providing data to them, there is more centralization in the whole organization. There is less

divisional or departmental autonomy than when each could process and utilize its own information, either in a punch card-tabulating machine system, or in a first generation computer. The advent of second generation computers, with larger memory files like the IBM 7040 or the Univac III (to mention examples in two large companies), broke down the old divisional and departmental walls and exposed traditional functions to a new information processing system on which each is now dependent for its operations.

The Impact of Electronic Data Processing in Life Insurance Companies

(This is a preliminary and brief report on a section of the project done by George E. Delehanty. A complete report of this investigation will be issued separately.)

This study is concerned with the effects of technological change on the occupation structure and the organization structure in a group of life insurance companies.

By most measures the life insurance industry has enjoyed a striking growth since the end of World War II. Without adjustment for price changes, the record shows that, from 1945 to 1964, total assets of U.S. life insurance companies have more than tripled; their total income from all sources has quadrupled, and life insurance in force in U.S. companies has increased by more than five times. Over the same period the number of U.S. life insurance companies has increased from 473 to 1,585*.

Against this background of growth there have been three major categories of technological change in this period. One is the proliferation of different types of life insurance contracts. In this category, the most important change has been the rapid growth in group life insurance that accompanied the postwar "fringe benefit revolution."

In the "production techniques" of the industry there have been two related but separable technological changes. The first of these was the development of more sophisticated punched card accounting machines and their accelerated adoption and use. In general the period of this change spanned the decade from 1945 to 1955.

Although still widely used, punched card processing began to give way, in life insurance operations, to the "first-generation" computers after 1955. Since that time, there is no doubt that electronic data processing has become a major focus of management interest. Electronic "hardware" and systems have been a major candidate for capital investment; decisions regarding EDP have been regarded as extremely important and planning and conversion functions have consumed large quantities of managerial resources.

* Institute of Life Insurance, Life Insurance Fact Book, 1965, is the source for these data.

This study attempts to analyze aspects of the experiences of ten companies relating to the effects of these technological changes. All are among the largest 100 life companies measured by insurance in force, have home offices located in the Northeastern United States, and generally do business throughout the entire country.

One research objective guiding interviews in these firms was the general subject of the speed of different firms in adopting the innovations represented by punched card and computer technology, the degree of their commitment to these changes and the type of accounting and management systems developed to utilize them. The industry has a relatively homogeneous set of products (basic life insurance contracts) and very similar functional requirements (e.g., premium collection and accounting, contract changes, benefit payments). Thus one would expect "new" technology to be quite rapidly diffused and for very similar "systems" to evolve.

It is difficult to find an appropriate standard by which to judge the experience of the firms studied. The first and preliminary conclusion reached in this study, however, is that there has been a great deal of variation in the rates at which the new technology is implemented, and surprising diversity of the systems designed to utilize the technology. This is true despite a relatively high level of exchange of technical information through formal and informal industry associations. At this point it appears that the differences observed are in part due to various historical influences. For example, some product differentiation may have occurred in the past which must still be "administered" as long as the contracts are still in force. In part also, the EDP systems may represent a new dimension of inter-company competition as some firms try to be leaders in the industry and others try to distinguish their "products" from those of their competitors either by the design of their EDP system or in ways that affect the system. Then, too, different firms appear to specialize in certain segments of the market. Although their product may not be technically differentiated, administration of the contract may vary in complexity and cost with the type of "customer."

This small sample of companies revealed some examples of this diversity. One large firm was a leader in adopting magnetic tape computers, and had one of the first "completely integrated systems" for debit insurance. Yet it appeared quite far behind several other companies in using the computer for group insurance applications.* A medium-sized company never completely converted to a punched card data-processing system. When they decided to adopt a magnetic tape computer they had to convert from what was essentially a manual accounting system. Their computer conversion was much later than most of their competitors. Yet their system appears more "integrated"

*"Debit" insurance is the industry term for what used to be called "industrial" insurance. The term refers to the accounting method, where the agent who visits policyholders to collect their premiums is held responsible for the monetary amount of his "debit."

and carefully designed than many others. Another smaller company has a sophisticated punched card system still in operation but has not yet successfully utilized a computer system despite conversion attempts covering several years.

In each of the cases cited here as an example, the causes of the situation mentioned appear to have been internal to the firm and not imposed by external or market forces. It would appear that further investigation of the factors which determined these different kinds of innovating behavior is warranted.

The impact of punched card and computer technology on levels of employment and the occupation structure was a major subject of this study. Although all of the data gathered have not been completely analyzed, it would appear that the following tentative conclusions are justified:

(1) The planning and conversion phases have two effects on the occupation structure initially. One is temporary; the other appears to be permanent; they offset each other in occupation profiles for the firms as a whole. Early in the planning stages, staffs of systems analysts, programmers and coders and liaison men have to be set up. In many cases it was thought that the size of these groups would be reduced upon completion of conversion. In no case, however, has this occurred. Changes in hardware, systems and "product" have apparently combined to keep the work load at a level requiring the full staff.

Quite large and temporary requirements for routine clerical workers and key-punch operators accompany the conversion of records from one form to another. In some cases this routine clerical staff has been built from workers whose jobs are supplanted by the machine. In other instances temporary and part-time employees are utilized for this purpose. Work force profiles taken during this phase thus reflect increases at lower skill levels and at the technical levels of the programmers and systems analysts.

(2) After a new system has been implemented, the clerical conversion staffs are disbanded, and, typically, other routine clerical workers are displaced. The net effect of the innovation thus shows up, in general, as a decline in both the absolute and relative numbers of persons at the low end of the occupation hierarchy. There appears to be a significant increase at the other end of the scale. Part of this, of course, comes from the added technical staff. But there are additional numbers of junior and middle-level managers not accounted for by the purely technical people. This may be due, in some cases, to "tandem" managers being appointed to supplement those who cannot adapt successfully to the changes. It may also be true that technical changes have focussed attention on other potential changes, and thus top managers have become aware of other uses for and substantial returns to "investment" in more and better managers.

(3) In the companies studied, home office administrative employment has tended to grow only slowly during the last decade. Numbers of sales people have increased, although not at the same rate as the volume of business. Different rates of growth in employment as between highly computerized companies tend to suggest that manpower requirements "per unit of product" have been reduced significantly by the introduction of computer technology. It is always difficult to relate cause and effect in these situations, but evidence at the division and departmental level within the firms supports this general conclusion.

(4) Labor market competition for scarce EDP personnel has created severe pressure on salary structures. Various methods have been adopted to deal with this. Firms that have found ways to increase relative wages for EDP personnel

now have satisfactory stability in their staffs. Others, attempting to maintain integrity of clerical salary curves, suffer from serious turnover in these categories.

(5) Dislocation problems among clerical employees, except in one company, do not appear to have been serious as yet. The dominant factor here is the composition of the work force. With a majority of employment in female, relatively unskilled clerical jobs the high rates of turnover allow attrition to handle most displacement problems. A few fairly serious problems have been encountered with displaced older male clerical workers. In these cases, length of service on specialized jobs has enabled them to reach salary levels which are too high to make for easy lateral transfer when displacement occurs.

Displacement of managers would appear to be a somewhat more serious problem. Historically a number of technical clerical specialists have advanced, slowly, to lower and middle-level management positions. Computer technology tends to make their technical skills obsolete. Without this expertise as a basis for their authority, and lacking the flexibility and in some cases the ability to master the new systems, many of these persons encounter serious difficulties. Almost without exception industry policy is not to demote such persons, but for them to retain rank and salary. In many cases other (frequently younger) men are moved in to do the manager's job with the ineffective person typically moved to a "staff" job.

Despite the apparent ease with which manpower adjustments have been made in the companies studied, one is left with the impression that as the latest generation of computer technology is implemented some more serious difficulties may appear. One of the reasons for this prediction is that in one company which undertook a major "rationalization" program with the aid of management consultants after establishing an integrated computer system, the reductions in manpower requirements appear to be striking. In a number of other situations one is led by formal and informal conversations to the inference that threats of organizational and employment disruptions are an effective constraint upon the rate of change. The general effect of this is probably delay. The logic of the efficient man-machine "system" design will probably dominate in the end. When it does, the potential for displacement appears to be great.

(6) The principal change in the content of clerical jobs appears to be a greater requirement for accuracy. There has been no apparent change, within given jobs, of the skill level. But it was very frequently reported that standards of accuracy and quality which were adequate for manual and even punched card systems have had to be revised upward for computer operations. A number of respondents indicated that they are trying to revise hiring and promotion standards upward. This is, however, apparently in anticipation of the greater flexibility in work assignments that is expected to accompany displacements and system changes in the future.

(7) As noted briefly above, difficulties in making changes in company organization structures appear to be a major constraint on the implementation of new computer systems. Most of the companies studied have a very active concern with planning and changing organization structure. One set of problems seems to arise from the existence of firmly drawn departmental lines which have, often through long and stable history, achieved considerable permanence in both formal and informal work flows and management relationships. These create a resistance to change "from the bottom up" as it were.

Still another type of resistance stems from the character of incumbents of vice-presidential positions at the top of departmental hierarchies. The industry

has not been accustomed to much mobility at higher managerial levels. Power and influence structures have tended to be relatively stable and predictable over time. In some companies, for example, the agency department has been dominant; in others the treasurer has been the most powerful force. Accompanying this and perhaps because of it, there was little mobility of managers between departments. This tended to restrict the training of managers, as well as their outlook. Understandably, then, there is a great deal of reluctance among managers at all levels to accede to changes which will modify this structure.

Despite these sources of resistance, the companies which have been most "successful" in utilizing EDP appear to have also been those who have succeeded in modifying their organization structure. In some cases changes have been made, then reversed, and then changed in a new direction. But even in the cases of these "errors" it would appear that more progress has been made than in the stable companies.

(8) Traditionally (and in the jargon of the industry) the sales of life insurance have been treated as "production." Now, however, it seems that computer operations provide another focus somewhat analogous to the "production line" in manufacturing operations. As systems are becoming more integrated and consolidated, the dependence upon the computer increases. With this dependence comes both resentment and interest and a desire to participate in control of computer operations. Some companies appear to be at a stage where attempts by various departments to retain or regain control of certain operations now performed by computers are creating serious problems. One of these difficulties is an apparent delay in implementing broader computer systems.

Other companies are attempting to treat EDP as a "service" operation, with "line" departments retaining functional responsibility. While this may succeed and endure for a time, it is doubtful that this structure can be maintained as more and more functions are added to those already performed by the computers. The line responsibility and authority will become quite hollow when accuracy, scheduling, and even the accounting and control system itself are the province of EDP. For reasons such as these, it would appear on preliminary analysis that EDP will grow to a role at least equal to that of the sales function. It may even turn out that, as "on-line" processing with immediate remote access to the central computer becomes a reality (as it undoubtedly will), the sales function will share the dependence upon the computer that other departments will already have felt.

(9) No single verdict appears possible at this time on the question of increased centralization with computerization. The kinds of evolution sketched in section (8) above can be characterized as centralization of sorts. In the companies studied, there appears to have been some recent transfer of record-keeping functions from the field to the home office. This, too, may be centralization. In terms of the important decisions of the firms, though, there appears to have been no discernible trend.

As direct access by field personnel to central data files begins to be used, my guess is that, so far as policyholder's services are concerned, more decision-making power is likely to rest with the field. They can be furnished with data and general rules, but there would seem to be substantial advantages in both speed and public relations to have customers' questions answered by the man who represents the company in most of their relationships with it.

In marketing, it would seem that strategies and techniques may be formulated at a higher managerial level. As more and better data are available, almost

instantaneously, more companies are undertaking statistical market analyses to guide their selling efforts.

As far as the investment functions are concerned there do not seem to be any strong reasons to think there will be any major change in the level at which decisions are made. Some studies relating to portfolio management are now being made, but there do not appear to have been any more centralized decision rules imposed now than in the past.

(10) Data on changes in the composition of managerial employment were not available for all companies studied. Where these figures were obtained, however, they showed no indications as yet of the predicted demise of the middle manager. To the contrary, it would appear that their numbers have increased rather sharply. This has been true despite a slow growth in total employment, so that it is not explainable by a fixed proportion relationship with "people to be managed." As noted above, it may be related in some cases to "tandem management" in functions undergoing conversion. While some added numbers appear to be those working in the EDP area, this is only a small fraction of the total increase. An increase in management "cadres-in-training" to handle expected growth and a heavy wave of expected retirements may also account for part of the phenomenon, as may the increased complexity in contracts.

(11) As companies have progressed through computerization, EDP appears to have moved toward higher levels in the organization structures. In some cases this has been done formally, with a new department being created with an EDP man made an officer of the company to head it. Other examples were found in which, through less formal arrangements, EDP management has been brought closer and closer to the top of the managerment hierarchy. In one firm a manager who successfully administered the EDP conversion was rapidly promoted to the number three position in the company. In another company a man with an early and deep commitment to EDP advanced rapidly through another department to be heir apparent to the top operating post. In still other instances, the man at the head of the EDP function, while nominally a "staff" man has <u>de facto</u> authority and responsibility far beyond this role.

It should be emphasized again that these observations, conclusions, and predictions are very much tentative in nature. They may be modified considerably as further study of the case material continues.

Less Divisional Autonomy: Crumbling of Departmental Walls

The studies of life insurance firms under integrated EDP systems pointed to this tendency. It has been noted earlier by other students and practitioners. For example, such companies as International Shoe, Standard Oil (New Jersey), General Electric, and others have reported these changes as a result of computerization (Shultz and Whisler). EDP makes such functions as sales, purchasing, production, marketing, finance, and personnel more sensitive to each other, and brings out more clearly their interrelationships and interdependencies. Forrester's analysis of industrial dynamics makes this interrelationship even clearer. Industrial dynamics "treats the interactions between the flows of information, money, orders, materials, personnel, and capital equipment in a company, an industry, or a national economy." (p. 13)

Departmental walls have come down in a number of cases, and old departments and/or functions have been combined. Under EDP, merchandizing and procurement are now functionally one unit (Shultz and Whisler). The John Hancock Life Insurance Company was the first to merge underwriting and issuance of new policies into a New Business Department which is described as "a highly coordinated and integrated team to handle, in conjunction with the machine programs, the entire production job for all but the relatively few applications for large amounts of insurance." (Ormsby, p. 17)

Whisler reports that in one U.S. company, the

> "product distribution function was significantly changed. Before the computer, more than thirty separate offices sold goods and delivered them to the customer--from warehouses that these offices managed. Credit management and production management were located elsewhere in the organization structure. After the computer, sales activities remained in the original offices, but distribution, credit management, and production control for the entire country were combined in one office under one executive." (IILS paper, 1964, p. 8)

While the company is not identified, it is certainly similar to the experience with Westinghouse's Tele-Computer Center, described recently in two reports (Burck, p. 37; Strauss, p. 65-69). The Westinghouse Center has been characterized by a company staff officer as "the world's first industrial application of a real-time computer to control a communications network." (Strauss, p. 65)

This long section on the consequences for management organization of the EDP total system concept may be summarized briefly in the following points: (1) there is increased management by rule and procedure, with less room for independent decision-making by lower levels of management; (2) there is consequently more centralization or recentralization of formerly decentralized organization structures; and (3) there is less divisional or departmental autonomy not only because of (2) but because the system concept weakens and crumbles departmental walls.

If we look to the future, however, the prediction of Bernard Muller-Thym is relevant:

> "The new kind of organization...exists in a kind of curved space, where points of competence mobilization, points of decision-making, and points of information management are so arrayed that one can go directly, or almost directly, from any action-taking, decision-making, information-handling point to any other point." (p. 43)

Whether this means more centralized organizational structures is not certain. One possible view is that the newer so-called "third-generation" computers (with real-time capacities and time-sharing) "will offer many companies the opportunity to reinforce decentralization and to use the creative talents of much larger numbers of their personnel." (Industrial Management Review, Spring 1965, p. 3). Burlingame suggested the same possibility earlier (p. 124). The possibility is at least worth exploring in future research, before we accept as completely proven the "centralization" conclusion based on experience with second-generation computers. This possibility is also related to the discussion in the next section, on the nature of managerial activities and work.

The Impact of EDP on the Nature of Managerial Work

Let us start with the proposition that the relative roles of managers and computers are affected (1) by the nature of the work that various levels and types of managers do, and (2) by the capabilities of the computer hardware and software (programming). The latter have changed greatly in the last ten years, and, as suggested at the outset of this paper, more sweeping changes lie ahead. So even if we can define accurately what managers do, we cannot say with certainty what part of their work will be replaced by advancing information technology. But we can say what has happened and is happening, based on past and present experience with EDP, as well as on predictions for the future.

There are many definitions of management, and descriptions of what managers do. One of the classic definitions has management engaged in planning, innovation, coordination, administration, and control. In his Industrial Dynamics, Forrester defines "managing" as "the task of designing and controlling an industrial system" (p. 8) and "management" as "the process of converting information into action. The conversion process we call decision making." (p. 93) But as Holt has pointed out in the discussion of Forrester's latter definition, the manager does more than "make decisions" - he also has to implement them: "A manager soon learns that the management role in a human organization involves a great deal more than just decision making." (Greenberger, p. 73)

There is validity in these definitions, as well as in Holt's comment. But decisions obviously differ in their content and difficulty. Elsewhere, Forrester has pointed out the qualitative characteristics of "decisions" made at some middle level of management:

> "It is in the middle-management levels that decisions are already highly routine and determined by formal policy and systems structure and precedents. Much of the middle-management structure is made up of frustrating and unrewarding tasks. The tasks are managerial in name only. They are actually steps in the information-processing production line. As these tasks are better understood, it will no longer be necessary to squander the talents of good men in these positions." (Greenberger p. 67)

These are the "decisions" which in the past have involved inventory and production control, purchasing, costing and pricing standard products, setting production rate and product mix, ordering from warehouses, and shipping to customers. In an increasing number of firms with EDP systems, these decisions are being programmed and handled without the necessity for repetitive human "decision-making." (Simon in Shultz and Whisler, pp. 50-54, Anshen in Dunlop, pp. 74-75, Burck, pp. 35-46, and others.) As pointed out earlier, a substantial amount of the routine underwriting and new issue work in life insurance has been programmed on the computer at the John Hancock Life Insurance Company. The experienced underwriters now work only on the more difficult cases which the computer cannot handle. (Ormsby)

Another example of routine decision-making by a computer is the following summary of what an integrated system can do in a large tobacco company:

> "Ninety per cent of their purchases for twenty-two different plant locations are made automatically by the computer, which maintains a master file of all vendors and transactions. Inventory status reports are maintained for 1,500 stock items, and orders are written automatically when stock levels drop to a certain point. This same company uses the computer to prepare detailed production and quality reports comparing actual performance with target performance by machine, shift, inspector, etc. Costs are compared with standards for each production run. Other 2,000 daily orders are automatically checked for credit against a master customer file, and written by the computer. Shipping documents are automatically printed out to replenish warehouse stocks when they drop to a certain level. The computer prepares up-to-the-minute sales reports giving how much of what was sold to whom in which territory." (Langstaff, p. 11)

But certainly not all managerial work is routine, even at the lower levels. In the study of the centralized inventory control system for parts reordering in a consumer durable goods manufacturing company, "the foreman (at the parts depot) is more concerned with 'pace setting and work pushing' than ever because his performance is more readily measured and the complexity of his job has increased. The depot manager's job, on the scale between the division manager and foreman, is both more 'difficult' and 'easier.' It is more difficult in the sense that the level of performance required of his depot is higher; it is easier in that he is better equipped with information and the measurement of his performance is much more objective." (Chabot, p. 57) Perhaps when the lower-level managers are relieved of routine tasks and paper-information processing, they can devote more of their time and talents to coaching, guiding, and coordinating the efforts of their subordinates. Even if the number of people in these ranks is thinned out by computer systems, we ought to study further the nature of the work done by those who remain. One study of the impact of EDP on middle management found that "an EDP system tends to expand the middle manager's personal contacts with his subordinate managers...they now have to spend more time on directing the work of their departments." (Shaul, p. 11)

In any case, Simon's succinct 1960 statement still probably applies:

> "The problems that managers at various levels in organizations face can be classified according to how well structured, how routine, how cut and dried they are when they arise. On the one end of the continuum are unprogrammed decisions: basic, once-for-all decisions to make a new product line, or strategies for labor negotiations on a new contract, or major styling decisions. Between these two extremes

lie decisions with every possible mixture of programmed and non-programmed, well-structured and ill-structured, routine and non-routine elements.

"There is undoubtedly a rough, but far from perfect, correlation between a manager's organizational level and the extent to which his decisions are programmed. We would expect the decisions that the president and vice-president face to be less programmed, on the average, than those faced by the factory department head or the factory manager." (from his paper in Anshen and Bach)

Anshen has listed nonprogrammed decisions in three categories: (1) those "concerned with finding problems that need to be solved and assigning priorities to them," such as recognizing inadequacies in a distribution system and taking steps to remove them, (2) those "concerned with selecting specific targets for accomplishment by the organization as a whole or its component parts," such as setting sales or profit objectives, and (3) those "involved with questions of implementation: what decisions can be executed most economically in view of available resources, time, and experience; how to get accomplishment through people; how to encourage innovation in a conservative organizational environment." (in Dunlop, pp. 75-76)

Some of these nonprogrammed decisions areas are in the "strategic planning" area listed as one of three managerial functions (the others being managerial control and operational control) by Dearden, who points out that business simulation through the computer may prove to be of considerable value. (p. 133) But it is difficult to conceive how computer simulation would help "to get accomplishment through people," or to plan a strategy in labor negotiations, or to encourage innovation. Skilled and experienced top managers also know a great deal about the idiosyncrosies of key customers or suppliers; or how to handle unpredictable events such as the death of a key manager, a machine breakdown, etc.*

Nevertheless, in this middle area of "ill-structured" managerial decisions, the new information technology combined with what is called the "non-management science" (including operations research, linear programming, and "industrial dynamics") will be increasingly important. For example, decision rules by coefficients based on past managerial behavior have been shown to be more efficient than continued management practices based on past experience. (Bowman) This assumes fairly constant conditions; for the rules

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*This point was made by Professor Donald Carroll at a symposium on Management Information Systems given by the Sloan School of Management at M.I.T. in April, 1965.

must be changed if conditions change. Simulation of managerial decisions on particular problems to select the best among several alternatives is another example. This merges into heuristic programs, in which the computer is programmed to improve its own program on the basis of experience - to approximate the human learning process. Simon and his associates have developed what they call The General Problem Solver, which "to put it simply, is a program that reasons about ends and means. It is capable of defining new subsidiary ends, or subgoals, to the original end." (Simon in Greenberger, p. 101) This is computer simulation of the "elaborate heuristics, or rules of thumb, that allow us to factor, approximately the complex perceived world into highly simple components and to find, approximately and reasonably reliably, the correspondences that allow us to act on that world predictably. This is the skill that the adult businessman uses when he makes a decision..." (p. 113) Minsky, commenting on Simon's paper, said, "...I have many reservations about accepting any theory that alleges to be an imitation of the human brain, since almost nothing is known about how the brain forms a concept, recognizes a pattern, and so forth." (p. 114) But later he concluded:

> "Within our lifetime machines may surpass us in general intelligence. ...We can discuss the subject of management rationally when considering information retrieval, simulation of companies, linear programming, and similar topics...But the prospect of machines that are better thinkers than we are is hardly a stimulant to sober discussion. It makes us feel that the problems of future management may be the machines', not ours." (p. 118)

The role of the human programmer, however, is stressed by Arthur L. Samuel, who invented the checker playing machine at IBM and later was beaten by it. In disagreeing with Norbert Weiner's suggestion that the computer of the future may "remove from the mind of the designer and operator an effective understanding of many of the stages by which the machine comes to its conclusions," Samuel maintained this position:

> "The so-called conclusions are the logical consequences of the input program and the input data, as revealed by the mechanistic functioning of an inanimate assemblage of mechanical and electrical parts. The 'intentions' which the machine seems to manifest are the intentions of the human programmer, as specified in advance, or they are subsidiary intentions derived from these, following rules specified by the programmer." (Science, September 16, 1960)

It is certainly possible that as psychologists and systems engineers are able to understand intellectual processes better, they will "be able to apply the computer to more and more tasks." (McCarthy in Greenberger, p. 227) In any case, it is likely that there will still be some sort of man-machine interaction, in which the manager, for example, can sit in front of a console or screen, put certain questions or propose tentative plans to the computer for answers or evaluation, then alter the questions or the plans on the basis of the instantaneous answers, get new answers or evaluations, and so forth. Much of this still lies in the future, although prototypes are being developed at M.I.T. and other centers. (Pfeiffer, "Machines That Man Can Talk With," Fortune, May 1964) An automatic management information system is also still to be developed. (Lombardi, p. 4)

Even if these developments should affect management work more rapidly than now seems likely, the "man" in management will still be important - even more important at some levels and in some tasks. The human brain in the form of an experienced and able manager is still a marvelous computer; EDP cannot exercise judgment - it can help a manager exercise better judgment on the basis of better and more accurate information. The computer can also assist managerial judgment and decision-making, through simulation, operations research, industrial dynamics, and other new tools of management.

Two examples, taken from one of the M.I.T. theses (by a Sloan Fellow), illustrate these uses of the computer:

> Large tobacco company - "is using the computer to an increasing degree to help management make advertising decisions. By mathematical simulation they are pre-evaluating the effectiveness of various advertising decisions. Advertising dollars are allocated to products and areas with the help of the computer, and progress is being made in measuring and evaluating the impact of the various advertising programs which the company has conducted."
>
> Chemical company - uses computers "in selecting the proper plant location at which to manufacture material for a given order. Linear programming models are used for all such products to weigh factors such as current raw material inventory, load schedule on equipment, cost of production, availability of storage facilities, required deliverty date, and shipping costs, to indicate the optimum location for manufacturing." (Langstaff, pp. 11-13)

Who makes the decisions on these types of computer systems? If top managers do not abdicate their responsibilities to specialists, they will determine the purposes and parameters of the systems design, with the advice

of specialists. The key manager of the future, in Forrester's phrase, will be an "enterprise designer":

> "He is the one who will be able to work with the way information sources and decision-making policy at each of the many points throughout the organization combine to create desired results." (in Greenberger, p. 66)

Whether this enterprise designer is actually a top operating man who has developed this capability, or a systems designer who later moves into top management because of his competence, is a question to be determined in thousands of companies in the years ahead.

This section on man-machine collaboration can appropriately end with a provocative statement in 1965 by the president of Yale University, Kingman Brewster, Jr.:

> "When the whirring of computers and the chatter of committees is done, someone decides--whether to advance or retreat, to hire, to fire, to expand or contract, to fish or cut bait, to reward or penalize, to buy or sell, to bluff or to call a bluff."

And, it might be added, once the decision is made, how and when to implement it.

The Introduction of EDP as a Problem in the Management of Change

The literature of industrial relations is full of examples of management success or failure in introducing changes affecting employees in the organization. The introduction of EDP, which is a major technological change affecting management (as well as clerical and production employees), is subject to the same degrees of success or failure. However, Anshen pointed out several years ago that:

> "Relatively little study has been devoted to what happens after the installation. But at least a few case histories suggest that results do not always proceed as anticipated. Problems that have been analyzed solely in terms of information processing are often complicated by other factors, such as individual and group motivations, pressure, and goal divergencies. The influence of these factors may persist--often in exacerbated form. These experiences urge adoption of a larger frame of reference than most technical specialists are inclined to use, a recognition of the human and functional interplay. To the extent that this view gains acceptance, the introduction of automated information processing is likely to be slowed and moderated as managers attain a more perceptive understanding of the intricate problems of man-machine relationships." (in Dunlop, p. 75)

Prior discussion in the literature and the preliminary studies done under the M.I.T. project suggest that the relative success of an EDP introduction depends on at least these four factors: (1) the involvement of top management in planning, explanation, consultation, and implementation of the change; (2) the role of the EDP center or unit, and especially its relationships with the departments and managers affected by the change; (3) the handling of management transfers, retraining, salary adjustments, early retirements, etc., and (4) the consequent "reaction" of the affected managers at points where dissatisfaction can interfere with the efficient functioning of the EDP system. This section will deal briefly with each of these points.

(1) The involvement of top management

Nearly every writer on EDP introductions has stressed the responsibility of top management, and sometimes even operating management, for deciding what kind of information should be generated by the system and for what purposes. The danger of leaving this decision to EDP specialists has been stressed. For example:

> "From an organization point of view, the most important characteristic of systems specification is that, as a general rule, it should be decentralized to operating management: that is, it should be controlled by the people who are to use the system." (Dearden, Harvard Business Review, March-April, 1965, p. 67)

> "The computer operator.....He is occupied with the how of the computing process, not the why of the project as a whole. So management is going to have to take over even more of the responsibility for determining just what the proper end product of its paper work ought to be." (Slater, Harvard Business Review, March-April, 1958, p. 174)

> "The job of the information system analyst is to provide economical and timely information upon the specifications given by management. ...(but) the kind of information which is drawn (e.g., exception reporting), the places where it is made available (e.g., who should receive which reports), and the way such information is utilized are matters of policy, not matters of system analysis. The golden rule of discipline of the information system analyst should be 'stay away from policy matters.'" (Lombardi, p. 12)

A study of computer introductions in 27 companies concluded that the difference between effective computer use and difficulties was principally in the involvement of operating management in the selection of computer projects, the manning of these projects, and the responsibility for overseeing the progress of the projects. (Garrity, p 6) In commenting on this study, Dearden

pointed out that while the data processing activity "can and should be centralized," the systems specification function "should be decentralized because management cannot delegate this responsibility to a staff group, because the work does not usually progress well when done by a staff group, and because the knowledge and capabilities required to perform these jobs are not usually found in staff systems specialists." (p. 68)

One of the companies interviewed for an M.I.T. thesis (by a Sloan Fellow) reported that separate plant computer facilities could only be integrated into one unified, compatible system "with the strong backing of the company president and other members of top management." (Langstaff, p. 29) A large chemical company with a number of operating divisions which had earlier established separate computer facilities, recently appointed a new executive vice president with the assignment to develop within 18 months "long range plans for the most effective use of computers to form an information system for the entire company." He is assisted in this task by a Corporate Computer Systems Planning Group. (Langstaff, p. 31) An early and successful integrated EDP system in a large tobacco company was explained by the statement: "We have the kind of top management which is willing to try new things and which has faith in the future. This attitude is absolutely essential to the successful implementation of computer programs throughout the company." (Langstaff, p. 56)

(2) The role of the EDP center

When computers were first introduced in multi-divisional and multi-plant firms, each division or plant tended to develop its own computer facility. Furthermore, since computers were first used for accounting and payroll functions, the computer was initially centered in the controller's department. Specialists were needed to develop systems and prepare programs; they often acquired control of the system simply because top and operating management seldom understood the computer processes and their implications.

Writing in 1962, Thurston observed:

> "I consider that in the past decade a significant characteristic of information-systems work has been too great a degree of control in the hands of specialists. This situation has developed in part through the failure of top management to place controlling responsibility with operating managers." (p. 139)

Nevertheless, as integrated, company-wide EDP centers are established, these centers necessarily acquire considerable power. The head of the EDP system in a large shoe company explained his view of his role at a 1959 seminar:

> ".....the planning and estimating system that we use is so pervasive and has behind it such full administrative control that we believe it is unrealistic to conceive of it as a staff function. Information technologists who build information systems of this sort are, in large measure, clearly indicating the decisions which other individuals in all departments must make." (Shultz and Whisler, pp. 151-152)

The same official asked the key question about implementing a conversion to an EDP system:

> "Who is going to effect all this? Someone must be the ramrod to make these changes take place....He must be one who understands the industry and his own company and is well acquainted with their ramifications. He must be one who has a concept, a philosophy of computer use, one who realizes that it is the system, the philosophy, and the concept that will bring about these changes; that it is through the application of the computer as a tool, not an end in itself, that these changes can be made possible.
>
> "But this individual alone cannot do it. He must have recognition and support from top management, for his plans can bog down in a welter of confusion, fear, and chaos unless his authority is well defined and supported to the high degree of cooperation that he requires." (p. 143)

The implication seems clear that "authority" is needed by the EDP specialist, and that if he is supported from the top he will get "cooperation" from others. At the risk of being unfair to the particular case, there is nothing in this to suggest that the EDP center should explain, persuade, educate, consult, or seek to get understanding among operating management of the purposes and advantages of a central computerized management information system. Nor is this need for implementation clear in the following statement:

> "By defining the objectives in detail and then obtaining acceptance of them by all key functional department managers, the president of the enterprise can be assured that there are no misunderstandings between the systems designers and the operating personnel." (Evans and Hague, p. 97)

On the contrary, there is good evidence that "the integration of systems calls for a high degree of cooperation by the various members of management responsible for the activities affected" (Grosz in Shultz and Whisler, p. 179), and this cooperation is not likely to be secured by "ramrodding" the new system down through the organization. The kind of involvement of top and operating management indicated in the preceding section is essential. Furthermore, as a series of British case studies has brought out, fear and apprehension are greatly increased when computer introductions are characterized by secrecy. (Mumford)

Granted that "those responsible for designing a new information system must know how to do a better job than is presently being done of delivering products or furnishing servies to their existing and potential customers" (Evans and Hague, p. 93), the question is: how should these people go about developing and implementing their designs? The evidence is piling up that the system designers need to work closely with key people in the affected operating departments.

One method used is to assign a competent operating executive from such a department to the systems design group. This method was used in a large insurance company, in which the departments first covered by an integrated data processing system were asked to designate a key man who could be temporarily assigned to the data processing center, thus combining the intimate knowledge of operating problems with the specialist skills of the systems design and programming people. This operating man can then work closely with his associates in the department as the new system is designed. There is no secrecy; the affected people are involved in the planning, and the subsequent implementation is smoother. The time elapsed between an initial decision to consider putting an operation on the integrated EDP system and the final implementation is as much as four to five years.

A similar approach is being used by the Travellers Insurance Company of Hartford, Connecticut, according to a recent report (Fortune, August, 1965, p. 208). An EDP system is being developed for the fire and casualty side of the business, with a battery of computers "which will eventually be hooked up, on a privately leased 'real time' communications network, with the company's 93 field offices throughout the U.S." This development is estimated to require

eight years for completion. "To avoid arousing the apprehension and resentment of the agent, the company makes a point of trying to accommodate the system to him, rather than demanding that he adjust overnight to the system. Also, there is the education that management, from the top down, must go through if the optimum potentialities are to be utilized."*

A report on the Louisville and Nashville real-time data processing system indicates a "five-year plan" for design and implementation, developed by a study group consisting of "some high powered traffic, operating, signal and communications men--as well as data processing and systems people.....We systematically draw on talent as we need it. Our operating department has had six or seven men assigned to our project for real-time operation----and without them we'd have been in a helluva shape." (Railway Age, April 26, 1965, p. 41)

In contrast, following a study by the systems people in one division of a large chemical company, the president wrote a memorandum directing that the production planning operation be computerized. "Although the head of the manufacturing division knew of the study, he neither participated in the final decision or knew about it until he received the memorandum. Undoubtedly, the fact that he was not included in the decision making contributed significantly to the hostile attitude which he showed toward the computer." (Langstaff, p. 44) The same study reports a different approach by the manager of the systems development department in a large tobacco company:

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* There is an interesting comment on the impact computerization has already had on management decision-making: "Some managers are already beginning to pre-test their decisions by the use of simulation techniques. As one department head says, 'The computer doesn't make the decisions for you, but it does illustrate the results of decisions within the possibilities --the alternatives--which you envision. We can now play the game of "what if?" and make better provision for the variables we are bound to encounter in such areas as interest rates, medical costs, accident frequency, etc.'" (p. 208)

> "...as a matter of strategy his department always tries to get the management of the operating department concerned to initiate the request for computer feasibility studies. In this way, a favorable decision to use the computer is almost always assured, and the management involved is receptive to the changes that inevitably must be made when the computer is used. ....In order to help the operating people come up with these 'ideas', the systems people meet with them periodically to keep them up to date on the type of things which the computers are capable of doing." (Langstaff, p. 45)

This experience demonstates the importance of the way in which the EDP center with its systems designers and programmers implements a change. It is not sufficient for technically-trained specialists to assume that because a new system is logically correct, all those affected will accept it without question. In the past in another area, this has too often been the mistake made by engineers who sought to introduce a change affecting production workers, and the opposition of these workers and their unions to abrupt technical changes has resulted in orderly procedures which have contributed to industrial peace and lasting higher productivity. This experience certainly has relevance to EDP, a technological change affecting management.

(3) Handling management transfers, retraining, salaries, retirements

Most reports on management policy state that no member of management has lost his job as a result of computerization. What this means is that managers whose work is largely eliminated, because it was largely routine anyway, are transferred, possibly retrained, maybe "kicked upstairs" to a featherbed job, sometimes demoted, and sometimes retired early. It is easier to be generous in this way to the relatively few members of management whose work is so directly affected that they do not retain their present jobs even though the jobs have changed.

The case study reported earlier of the computerized inventory control system in parts distribution in a large consumer durable goods manufacturing company showed the extent of the transfers and other personnel actions in the depots and in the home office. (Chabot, pp. 36-40) They were substantial, and affected particularly those in the lower salary grades. Among the affected depot supervisors, there were three promotions, but eight were affected adversely. The latter were mostly supervisors with lower performance ratings, and of the eight, two quit, three were demoted, and three were retired.

Transfers to other depots were offered to the longer-service employees, and moving expenses were paid. Altogether, the policies followed were not unlike those which the same company used with its unionized production workers, and no adverse reactions were reported - although the adversely-affected supervisors were apparently inevitable casualties of the EDP system.

One other consequence should be noted. The supervisor's and depot manager's jobs were upgraded in the sense that they now had to understand the logics of the EDP system, and train their subordinates in its requirements. This limited the possibility of promotion from the ranks, and forced the company to recruit supervisors from depot and central office personnel who showed potential ability and also from some college graduate trainees. One superintendent said: "The demand is for a foreman with more technical ability and not a loud voice." (Chabot, p. 54)

The importance of better training is clear. Not only do managers under EDP need to understand its requirements, but if they are to be involved in planning the introduction from the start, they are forced to re-educate themselves with the help of patient EDP specialists. And, since many of them will be in the "input" part of the system, their understanding and cooperation are essential. In the Louisville and Nashville Railroad EDP "real time system" the "debugging effort had moved in tandem with a massive educational program carried on to educate L & N operating and yard forces to use the machines that keep the computer center at Louisville informed within minutes every time a wheel turns on the railroad." (Railway Age, April 26, 1965, p. 37) This is still proceeding as a part of the programmed progress toward real-time operation by 1969.

In another case study (reported by an M.I.T. Sloan Fellow's master's thesis), the conversion to an EDP system involved mistakes in personnel selection and training. Probably these mistakes occur more often than the published literature indicates, so it is instructive to consider briefly what happened in the paint division of a chemical company. A man with 25 years' service was selected to head the new Paint Data Processing Department. His most recent job was as a supervisor of paint shipping, which required a great deal of record keeping and expediting, in addition to handling shipping arrangements. "The fact that the importance of the shipping job would be

greatly diminished in the new set-up, undoubtedly had some bearing on his selection for the new job," the report adds. But the man selected "had never seen a computer," and during the year between his selection and the first operation of the computer, "there was no time off from his job to work with the systems people on the new data processing set-up which he was to manage." He went to an IBM training school for two weeks, but his prior background was inadequate and added to his fears about the new assignment.

When the computer operation began, he was really on the sidelines: "He found that he could hardly make a move...without first checking with the systems people. Many times he would make a suggestion only to be told by the systems men that it wouldn't work, or that they had in mind another change in the system which would make his suggestion unnecessary." Presumably the EDP system has proved its worth in other respects, but the new EDP supervisor is clearly misplaced. His feelings about the job are ambivalent. The job "is more challenging now than before" but he lacks confidence in his decisions. "He also has closer control from higher management than before."

Of course, it is not always true that older members of management cannot make the transition to an EDP system. These studies cite examples of success stories as well as cases of "voluntary early retirement by members of management who decided that it was not worth the struggle to learn new ways of doing things after years of carrying out the job in a way that they knew well." (Langstaff, pp. 72-73) But those operating managers who do learn to work with the new system literally have to "go back to school" - either in the process of working with the EDP systems people in developing a system applicable to their area of responsibity, or by going to a school run by a computer manufacturer, or both.

The Consequent Reaction of Managers at Critical Points

In part, the reaction of managers at various levels affected by an EDP conversion will depend on the individual, his background and his outlook. But it will also depend on the skill with which top management and EDP specialists handle the introduction and conversion, as we have noted earlier. Perhaps in the long run it is not important how individuals react; one view holds that if they fail to adapt, they will eventually be displaced and the managers who

replace them will be those who have the background, the skills, and the determination to work with and utilize the new system. However, the transition period during a technological change offers opportunities for some affected people to resist, to drag their feet, to withhold vital information, and even subconciously to attempt to sabotage the system by introducing erroneous or incorrect inputs. (Rush, in Shultz and Whisler, pp 208-209)

An EDP system requires uniform, precise, written definition of instructions, some of which were previously verbal. The EDP staff specifies these instructions.

> "The mere presence of so much staff activity is disturbing to the functional manager....Their activity subjects the department manager to possible outside criticism. Their analyses may scrutinize his detailed procedures, which sometimes are defensively designed because of 'weaknesses' in other functional areas. Thus, the entire company may be shaken as a result of old wounds being opened and some areas of uneasy compromise becoming outright challenges. In some cases this may appear intolerable to various functional areas, and several may join forces in a united front to resist the methods and programming staff." (Fiock, p. 91)

Under these circumstances, operating managers tend to see the EDP staff and the forthcoming EDP system as a threat and react accordingly. (McGregor, in Shultz and Whisler, p. 116) This was true of the older manager of Paint Quality Control in the Paint Division of a chemical company. His operation was changed by the projected EDP system, so he "decided from the beginning that the change was wrong and that he was going to oppose it at every opportunity. By thought, word and deed he showed his disapproval. When mistakes were made which could be blamed on the computer, he spread the news. He made no effort to cooperate and was visibly agitated on numerous occasions involving encounters with the computer. About a year after the computer was installed, this man had a heart attack." This was perhaps an isolated instance, but the initiative for the EDP system came from corporate management and not from the Paint Division itself. Indeed, the head of the Paint Division "neither participated in these final decisions nor knew about them until this memorandum (stating a computer would be installed) was written." In preparing for the change, "the production people were not consulted at all. At this point there was a great deal of resistance by the operating people to the change to computers.....the systems people were working under a tremendous

handicap without the active cooperation and encouragement of the manufacturing people. This attitude is exemplified by an operating employee's remark to a systems man: 'You're so smart, you figure out how to make it work!'" (Langstaff, pp. 115-118) (For similar examples, see Karsh and Siegman, pp. 144-145 and 150)

In other cases, there seems to be a cycle of resistance, then acceptance. In the parts re-ordering system in the consumer goods durable manufacturing company, "the resistance was strong and continued to some degree for two years. Eventually, as experience with the system was acquired and investigation of errors did confirm the computer was 'right', effort was diverted from challenging and rechecking computer reports into corrective action." (Chabot, p. 52)

If there is such a cycle, its course can be shortened by some of the approaches outlined in earlier sections for top management and for the EDP specialists, in particular. If there is a background of confidence between managers and subordinate managers, and between line and staff, the changes resulting from an EDP introduction are much more likely to be accepted by those directly affected. Indeed, EDP may even be welcomed under such conditions as the following:

1) If the organization has been accustomed to changes in the past, and the new change is seen as another aid to management in servicing customers, suppliers, etc. An example is the experience of the Atwood Vacuum Machine Company (as reported in Shultz and Whisler, pp. 235, 240). A second example is the series of advertisements showing how the John Hancock Life Insurance Company's computer facilities provide the insurance agent with better and faster data to service the insured and potential insured.

2) If the EDP unit and the services it provides are seen as part of the management team, and not primarily as a centralized control mechanism. The change may be regarded as giving managers more certainty about the limits within which they <u>can</u> exercise initiative and make decisions, freed of routine paper work. Possibly something like this seems to have occurred in three general office departments of a large shoe company, as reported in a research paper analyzing the work attitudes of the 21 managers and 19 clerical workers who remained on the same job from 1955-56 (when the decision was made to install an EDP system) to 1963, when the interviews were held:

> "In general, then the study's findings indicate that EDP tends to set up a rigid work environment in which employees find less freedom and control over their own work. Nevertheless, they seem to be well satisfied with their new working conditions. Their increased knowledge about what they are supposed to do on their jobs and the apparent confidence in their work performance growing out of their better understanding of the interrelationship between their jobs and those of others appear to play important roles in this increased work satisfaction. As the study shows, the managers whose job it is to coordinate the different phases of the work are especially pleased with the greater consistency and predictability in the intra-and interdepartmental work flows paced by the computer." (H. C. Lee, Personnel, March-April, 1965, p. 77)

This finding seems to cast doubt on the first part of the prediction that middle and lower managers would find their jobs less interesting, while those of top management, systems designers and even lesser EDP personnel would be more challenging. More research on this is needed, before we can conclude that middle and lower management jobs are always reduced in numbers, in significance, and in job satisfaction. Nevertheless, the evidence seems to be that systems designers and their associate specialists regard themselves as on a new management frontier, working on challenging and exciting problems, and seeing the results of their work having a signficant impact on the efficiency of the organization. Their job satisfactions are correspondingly high, except when they run into managerial resistance and withholding of information, or feel that they lack sufficent backing from top management (as in the example mentioned earlier of difficulties in introducing an EDP system in the Paint Division of a chemical company. Langstaff, pp. 128ff).

One final comment should be made on the impact of EDP on the numbers of managers required at various levels. If we include "staff" managers, the EDP personnel required are always greater. In some cases, the numbers of middle managers (presumably operating or staff department managers, such as production planners, schedulers, purchasing men, etc.) are reduced (Lee, p. 75; Chabot, Ch. IV). In another study of nine life insurance companies, the numbers of middle managers were increased (Delehanty study at M.I.T., incomplete; also Goshay, Ch. 3). But it is probable that the number of managers per X dollars of sales (or some other similar measure) has decreased, just as clerical employees by the same measure have decreased in number.

Some Concluding Questions: The Impact on Management Motivation and Development

We can assume from the discussion in all of the preceding sections that as EDP installations move toward the "total system" concept, there is likely to be increasingly centralized control of operations, requiring specified procedures and limiting the discretion of subordinate managers. The interdependence of parts of the organization is increased, or at least clarified, and rigid departmental walls are broken down. Organization structures appear to be more centralized, and the nature of managerial work is changed to remove those parts which were routine, repetitive, and, therefore, programmable. In the present state of computer technology, and in the foreseeable future, it seems likely that many types of "unprogrammable" managerial decisions will escape the computer's impact, although the use of simulation techniques with computers may narrow the range within which these decisions have to be made. The central questions will continue to be the changing relationship (and combination) between the manager and the computer.

The possibility of management resistance, restriction of computer inputs, and non-cooperation with EDP systems people still plagues the introduction process, which is a problem in the "management of change." The possibility of a cycle of resistance, then acceptance, suggests the importance of approaches and attitudes on the part of the change agents (top managers and EDP staff) which would shorten this cylce. Two hypotheses being tested in research in the M.I.T. group are (a) problems of role conflict and role ambiguity which occur during an EDP conversion, and (b) managers who are "high" on "consideration" (i.e., practice participative management) prior to the conversion, but who increase in "structure" (i.e., become more directive) during the conversion, will experience less role conflict and role ambiguity than managers with other approaches or styles. (Meredith, doctoral research, 1965-66)

The possibility of resistance may also result from EDP's impact on the expectations of educated people. As the level of educational attainment rises in all advanced industrial countries, and especially in the United States, the prospect of a reduction in the number of significant and satisfying jobs because of the computer is a sobering one. Will the increase in the numbers of enterprise designers, systems people, programmers, etc., plus those in

top management whose jobs will be even more challenging, equal the increased supply of educated people seeking challenging jobs in private and public organizations? The answer of the economist, looking over the long period, is that technological changes have, through the market mechanism, increased employment rather than reduced it in the economy as a whole, and that skills have been upgraded. But what happens in particular industries and firms is less predictable, and in the short run, the adjustment problems in the economy as a consequence of a technological change as pervasive as the digital computer are still likely to be substantial. One need not be as pessimistic as Norbert Weiner in The Human Use of Human Beings (1951) to recognize the problem.

Another unresolved question on the impact of EDP is: how will it affect (a) the motivation of managers to superior performance, and (b) the development of future managers? These two sub-parts are interrelated, for if the motivational impact is not wholly favorable, then younger managers may not have the same opportunity to develop experience and show initiative for higher managerial positions. On the other hand, perhaps EDP will mean that there are new avenues to top management, via the systems design route rather than via operating management.

The new information technology combined with a management control system can provide top management with more prompt and more accurate data on the performance of sub-units, as we have noted earlier in this paper. But how will top management use this information, which may be limited to "exceptions" from the standard performance expected? Will the subordinate managers (the managers of sub-entities) also have this information on their own unit's performance, and will they have it at the same time as top management receives it, or even perhaps earlier? Is it important who gets the information first, and who takes action first?

Research in the behavioral sciences suggests the possibility that subordinates are motivated to higher performance if they share in the development of their objectives and can exercise self-control over their accomplishment. This is similar to Douglas McGregor's well-known Theory Y, as contrasted to Theory X (management by centralized direction and control). McGregor's insights find support in the empirical research of the Likert group at the University

of Michigan (cf. Rensis Likert, New Patterns of Management), as well as in studies by Whyte, Roethlisberger, Argyris, and others. More recently, some behavioral scientists have begun to doubt the general applicability of these concepts, preferring to relate the nature of effective management to the task at hand - whether the work supervised is routine and repetitive, or is creative and problem-solving, as in research groups (Bennis, Schein, Vroom and others). But there would be little question among behavioral scientists about the applicability of the McGregor-Likert concepts to managers whose work is not primarily routine or repetitive and whose jobs contain "non-programmable" elements within limits established by organizational objectives and controls. It is to these kinds of subordinate managers that the above questions apply.

Some writers have suggested the dangers in using EDP to provide top management "with information that it can only use to check up on operating management. And if top management uses this information to try to control operations, it will be performing the function of the operational manager. A company will end up in the ludicrous position of having two groups performing the operating function and no one handling strategic planning or management control." (Dearden, 1964, p. 134) "It is conceivable that the tapes could be read on orders from upper management without the knowledge of the departmental manager....the resultant feeling of exposure which confronts the operating manager contemplating these facts is appalling. Given some time to worry, he may well come to this conclusion: 'My data could be picked up, read, misunderstood, and I could be fired without ever knowing why!'" (Fiock, p. 92) This was also the view expressed by a systems man in one of the companies interviewed for an M.I.T. Sloan Fellow's thesis:

> "Because of the computer, there is a very definite danger of over-control from the top, since top management can get detailed reports on the operations. It is easy for top management to misuse these reports and not allow managers at lower levels to develop properly through the experience of making their own decisions." (Langstaff, p. 80)

Perhaps top management needs to practice forbearance in utilizing these data to get tighter control over subordinate managers. The Westinghouse Telecomputer Center has been described as providing real-time capability "so that top management may exercise control at their discretion at any level

in the organization for which performance data and projections have been provided." (Strauss, p. 69, italics mine) General Motors is reported to insist that its policy is to remain decentralized, using EDP strictly for communications. (Burck, p. 104) Shop managers and supervisors at Lockheed under a real-time computer complex are able to query the computer "for job orders, location of materials, production schedules or other daily operating information," thus "sharpening the timing of decisions at supervisory levels all through the cycle." (Business Week, March 27, 1965, p. 167) These examples all suggest the possibility of using EDP to permit lower management to continue to exercise some decision-making authority, within limits.

One advantage of continued decentralization of authority for decision-making in sub-entities has been indicated by Zannetos, who suggests giving these managers some time to utilize information provided by the centralized EDP system to take corrective action before they are exposed to checks and queries from above. (Paper "On the Theory of Divisional Structures" and talk at M.I.T. Industrial Liaison Symposium, April 27, 1965) True, this decentralization may be achieved at a higher cost in more slack in the system (e.g., higher inventories), but decentralization combined with management by objectives and self-control (via EDP) may have offsetting advantages in motivating people and measuring their performance more objectively for reward purposes. In any case, existing research has not pronounced the final verdict on this question.

The "third generation" of computers may introduce different technological possibilities. These may strengthen centralized management control (as suggested by Ever, p. 78). Or, they may help to reinforce decentralization by giving managers at all levels access to information on which they can base decisions. (Industrial Management Review editorial, Spring 1965, pp. 3-4)

Quite possibly, as suggested earlier, the impact will differ in different organizations as a consequence of the prevailing managerial philosophy. If top management has been uncomfortable under decentralization, because it did not quite know what was happening in the sub-entities and lacked full confidence in the capacity of these managers to make decisions or to report results, then EDP offers a technological opportunity to re-centralize and regain centralized control. On the other hand, if management values the

capabilities and potential capacities of subordinate managers in charge of branches, regions, plants, agencies and other sub-entities, it will endeavor to utilize the new information technology to provide them with better information to improve their decision-making without the necessity for close control from the top. If this managerial philosophy stresses management by objectives and self-control (Theory Y), there will be a reluctance to over-control from the top despite the availability of the technology to make it possible.

This general level of analysis, of course, overlooks some of the points made earlier in this paper. Some decisions will be centralized, largely because they are fairly routine and programmable. Among these are production scheduling, purchasing, accounting, inventory control, shipping, payrolls, and others. The computerization of routine underwriting in life insurance is another example. But some managerial decisions are not programmable, and are not likely to be centralized. Indeed, it has been pointed out that EDP frees managers at various levels of routine work so that they can devote more time to those parts of their jobs which involve advance planning, and developing more workable relations with subordinates, colleagues, superiors, customers, suppliers, government officials, and others in the outside environment (among which union representatives should be included!).

If routine decisions and operations are computerized and hence become more centralized, while other types of decision-making are still decentralized under EDP, can we say there has been more centralization, or more decentralization? And, if some decisions formerly made in the branches are now made in the regions, while others formerly made at the home office are now regionalized, is there more (or less) centralization?* The mere asking of these questions indicates the great difficulty of being precise about (or measuring) the degree of decentralization, recentralization, or centralization under EDP at any one time. But they are certainly worth exploring qualitatively in future empirical research.

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* I am indebted to my colleague, Douglass V. Brown, for suggesting these as important questions.

In any case, the new information technology represented by EDP has made management more rational, and less likely to be run by "the seat of the pants" or intuition. Managerial decisions will increasingly be made within a policy system integrated through a management information system. Whether the conditions of this system will nourish the development of managers from subordinate operating levels, or will draw managers from a different source within the organization or from outside (from the systems designers and their associates), is again a matter for reflection and research, as well as for prediction. (Cf. Burck, quoting Whisler, p. 109, and Shultz and Whisler, pp. 27-28) But no one familiar with what the computer has already done to management could dispute the title of the recent Fortune article (August, 1964): "Management Will Never Be the Same Again."

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